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A Study of Performance of Bio-Gas Plant

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ABSTRACT

Today we primarily use fossil fuels to heat and power our homes and fuel our cars. It is convenient to use coal, oil, and natural gas for meeting our energy needs, but we have a limited supply of these fuels on the Earth. We're using them much more rapidly than they are being created. Eventually, they will run out. Today there is a burning need of an alternative for fossil fuels because the fossil fuels are getting extinct. Hence it is necessary to find out alternative source of energy. This topic will make us aware that press mud which is a waste of sugarcane industries can be used to produce biogas. In order to produce biogas from press mud, press mud is allowed to ferment anaerobically in a digester for 3-4 hours at a temperature of 35-40˚C. Constructional details, process details and composition of required input are elaborated later. The biogas produced from this process is further scrubbed to remove the sulphur content for being used as a fuel. Furthermore this plant can be mounted on a skid so that biogas can be produced anywhere and at any place. As in India, especially the western Maharashtra is known for its sugarcane production, this idea may play a vital role in India.

Keywords: Biogas, Digester, Fermentation, Press mud

1. INTRODUCTION

We often call renewable energy technologies "clean" and "green" because they produce few of any pollutants. Burning fossil fuels, however, sends greenhouse gases into the atmosphere, trapping the sun's heat and contributing to global warming. Climate scientists generally agree that the Earth's average temperature has risen in the past century. If this trend continues, sea levels will rise, and scientists predict that floods, heat waves, droughts, and other extreme weather conditions could occur more often. We all know that biogas is good alternative for fossil fuels. Therefore, use of biogas should be done as much as possible. Much work has been carried out in obtaining biogas from various sources like kitchen, human, animal and agricultural wastes. The plants constructed for these purpose are working successfully too. Such plants are now-a-days being used by many people locally for obtaining biogas. As biogas is a non-polluting and renewable energy resource, it is efficiently replacing the LPG. The work proposed in this paper is to obtain biogas, not from the above mentioned sources but from a completely new source i.e. sugarcane press-mud. Press-mud which is also called as filter-cake is rich in methane which is the major source of biogas. This press-mud is usually dumped as garbage. Some sugar industries make use of it by converting it into compost. But this compost, along with its advantages, has some disadvantages too. It increases the wax content in the soil. The increase in wax reduces the porosity of the soil causing clogging which is not desirable. Therefore, making use of press-mud for the production of biogas is a better option. The biogas obtained can be used for many purposes like fuel in kitchen to replace LPG, fuel for powering vehicles, etc. The matter remaining after extracting biogas from press-mud can be used as a fertilizer as well. In this project we have made an effort to prepare a skid-mounted plant of obtaining biogas from press-mud [1-3]. The purpose of skid mounting is to make people aware of the use of press-mud by conducting the test wherever required. Also further processes like scrubbing, if carried out, can increase the efficiency of the biogas obtained. Scrubbing includes removal of sulphur di-oxide and carbon di-oxide.

2. TERMINOLOGY

2.1. Press-Mud

Press mud is a solid residue, obtained from sugarcane juice before crystallization of sugar. Generally press mud is used as manure in India. It is a soft, spongy, lightweight, amorphous, dark brown to black colored material. It generally contains 60-85% moisture (w/w); the chemical composition depends on cane variety, soil condition, nutrients applied in the field, process of clarification adopted and other environmental factors. Press mud from sugar factory typically contains 71% moisture, 9% ash and 20% volatile solids, with 74-75% organic matter on solids. Sugar molasses has methane potential (i.e. CH_4 per ton of raw material) of 230 m^3. Typical composition of press-mud is given in table 1. The present methods for disposal of press mud are not economically suitable and pollute the environment. As it contains appreciable proportion of biodegradable organic matter, it has very good potential for the production of biogas.

Table 1

Composition of Press-Mud

S. No	Compound	Percentage
1	Cellulose	11.4
2	Hemi cellulose	10.0
3	Lignin	9.3
4	Protein	15.5
5	Wax	8.4
6	Sugar	5.7
7	Na	0.22

Table 2

Characteristics of Press-Mud

S. No	Parameter	Average Value (%)
1	Moisture	76.3
2	Volatile matter	76.6
3	Sugars	6.4
4	Wax	7.2

5	C/N ratio	14

Table 3
Composition of biogas

S. No	Compound	Percentage
1	Methane (CH_4)	50-75
2	Carbon dioxide (CO_2)	25-50
3	Hydrogen Sulphide (H_2S)	0-3
4	Hydrogen	0-1
5	Nitrogen	0-10

Table 4
Effect of Substrate

S. No	Substrate	Gas yield (l/g)
1	Press-mud	0.241
2	Press mud: cow dung (2:1)	0.202
3	Press mud: cow dung (1:1)	0.167
4	Press mud: cane pith (2:1)	0.290
5	Press mud: cane pith (1:1)	0.381
6	Press mud: bagasse (1:1)	0.273

2.2. Bio-Gas

Bio-gas, a clean and renewable fuel, has vast potential in India. It can be a supplement to petroleum products, if used in compressed form in the cylinders. Biogas originates from bacteria in the process of biodegradation of organic material under anaerobic conditions. It consists of a varying proportion of CH_4 (methane) and CO_2 (carbon dioxide) and traces of H_2S, N, CO, O, etc. The content of CH_4 and CO_2 is a function of the matter digested and the process conditions like temperature, C/N ratio, etc. Methane is the most valuable component under the aspect of using biogas as a fuel; the other components do not contribute to the calorific ("heating") value and are often "washed out" in purification plants in order to obtain a gas with almost 100% CH_4.

2.3. Benefits of Biogas Technology

(a) Renewable energy source
(b) Reduced greenhouse gas emissions
(c) Reduced dependency on imported fuels
(d) Waste reduction
(e) Job creation
(f) Flexible and efficient use of end biogas
(g) Pollution free fuel

2.4. Fermentation

It is a microbiological process of decomposition of organic matter in absence of oxygen. The main products of this process are biogas and digestate.

2.4.1. Hydrolysis

The organic macromolecules break up into simpler elements - solid waste thus is liquefied and hydrolyzed in small soluble molecules (e.g. the cellulose is transformed into soluble sugars such as glucose or cellobiose.

2.4.2. Acidogenesis

During acidogenesis, the products of hydrolysis are converted by acidgenic (fermentative) bacteria into methanogenic substrates. Simple

sugars, amino acids and fatty acids are degraded into acetate, carbon dioxide and hydrogen (70%) as well as into volatile fatty acids (VFA) and alcohols (30%).

2.4.3. Acetogenesis

The products resulting from fermentation require an additional transformation before being able to produce methane. It is here that intervene the acetogenes reducing bacteria and the sulfato-reducing bacteria, producing hydrogen sulphide (H_2S).

2.4.4. Methanogenesis

The ultimate phase during which two types of methanogenes bacteria take over: the first ones (acetogenes) reduce methane acetate, CH_4 and bicarbonate. The second ones reduce methane bicarbonate.

2.5. Scrubbing

Raw biogas produced from digestion has roughly 60% methane and 29% CO_2 with trace elements of H_2S, and is not high quality enough to be used as fuel gas for machinery. The corrosive nature of H_2S alone is enough to destroy the internals of a plant. The solution is the use of biogas upgrading or purification processes whereby contaminants in the raw biogas stream are absorbed or scrubbed, leaving more methane per unit volume of gas. The main method of biogas upgrading includes water washing. The most prevalent method is water washing where high pressure gas flows into a column where the carbon dioxide and other trace elements are scrubbed by cascading water running counter-flow to the gas. This arrangement could deliver 98% methane with manufacturers guaranteeing maximum 2% methane loss in the system. It takes roughly between 3-6% of the total energy output in gas to run a biogas upgrading system. Removal of sulphur can be carried out using wet scrubbers. The gases to be cleaned are admitted tangentially into the scrubber which will also help in separating the particulate matters. Water spray absorbs these gases and particulate matters which collect on the surface of the scrubber are washed down by water and this water is further treated, filtered and can be reused.

Merits

- The collection efficiency of the scrubber is about 90%.

Demerits

- The pressure is high.
- Water used, after dissolving sulphur oxides will contain sulphuric acid and sulphurous acids which may corrode the pipelines and the scrubber itself. This water cannot be let down into rivers.

Figure 1
Perspective View of Bio-Gas Plant

2.6. Proposed Work

For the purpose of testing whether biogas really comes out from press-mud, it could be conducted that a small experiment. It took a cylindrical 4 liter paint vessel with its cap. This paint vessel was to be used as digester. The cap contained two circular holes- one of which acted as an opening for fitting the inlet pipe. The other opening, which was quite in the middle of the cap served dual purpose- for inserting the stirrer and also for collecting the out-coming gas. A hand stirrer was inserted inside the vessel and over it; a large balloon was fitted upon the opening. Stirring was done by holding the balloon and the handle of the stirrer together and then

giving it a stirring motion. The gas released after the reaction was collected in the balloon. In the other opening, a pipe was fitted which on its other end was connected to another small vessel. This small vessel was used as inlet tank. The cap with above mentioned arrangements is fitted over the vessel. Initially, the vessel is completely filled with water to remove the air, because the condition required for fermentation is anaerobic. Then this water is drained out. A feed of slurry containing press-mud and hot water is prepared in the inlet tank and fed through the inlet pipe. The temperature of the slurry should be maintained at 35˚C to 40˚C. Stirring should be done 3 to 4 times a day for a time span of 5-7 min. It is observed that after 4-5 hours, the balloon starts inflating. In about 12 hours, the balloon is completely inflated. This shows that biogas is coming out of the reactions taking place in the vessel which is shown in figure 1.

3. CONCLUSIONS AND RECOMMENDATIONS

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